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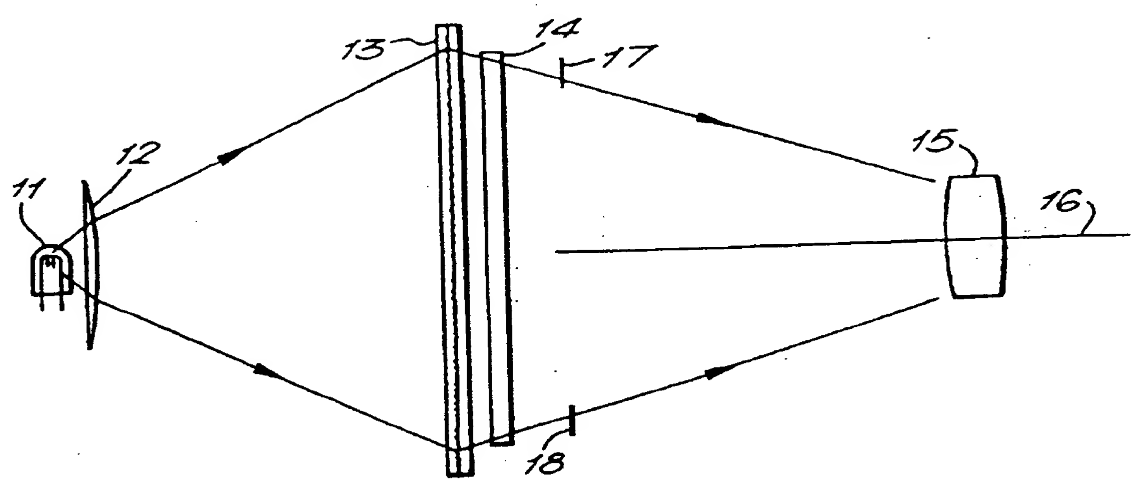

(57) Abstract

For use with an adjacent like projection apparatus, a projection apparatus having a luminous object such as a liquid crystal display panel (14) illuminated by a lamp (11) and condensing system (12, 13), and an optical projection system (15), is provided with at least one mask (17) which is comb-like and has its tines extending into a marginal region of the light to be projected from the object (14). The mask (17) is held stationary at a selected distance from the panel (14). The marginal decrease in light in the projected image is overlapped with the corresponding region of the adjacent image from the like projection apparatus. The tines of the mask are substantially triangular and have substantially no gaps between their bases.

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EDGE-BLENDING OF PROJECTED IMAGES

This invention offers an improved means of blending together adjacent edges of images projected by multiple projectors to create the illusion of a continuous picture. Such multi-projector displays are commonly found in training simulators and in the entertainment and advertising industries.

One known technique used in video/graphics projectors uses additional circuitry in the video chain to fade the video amplitude in a controlled manner at the edges of the picture. A linear falloff in brightness at, say, the right-hand edge of one image is overlaid by a similar linear rise in brightness at the left-hand edge of the next image. In theory, these two brightness ramps combine to give a constant total brightness across the picture boundary, giving the impression of a continuous picture.

In practice, an inconspicuous blend between pictures depends critically on the set-up of the two projectors in terms of picture geometry, colour convergence, brightness and colour balance. It is especially difficult to obtain a good blend for both dim and bright scenes. Because the projectors are not perfectly stable, blend quality deteriorates as the projector set-up drifts with time and temperature.

Another known technique, used for instance with slide projectors, is the soft-edge mask. An additional transparency is placed over the slide. This has a high optical transmission over most of its area, but the transmission falls off linearly over the region of the image to be blended. This produces the same linear fall-off of picture edge brightness as in the electronic method described above.

However, the mask needs to be precisely positioned to achieve a good blend. In any but the simplest installations, each blended edge of the picture will require its own, independently moveable, mask. Each mask will block about 10-20% of the projected light, even in its central "transparent" region. The mask must cover the whole of the slide, otherwise the physical edge of the mask shows up in the projected image as a step change in brightness. (The area of the picture not covered by the mask does not suffer the 10-20% light loss.) A

picture with 3 edges to be blended would require a stack of 3 masks. In many cases, the associated light loss is unacceptable. Attempts to reduce the losses and guard against long-term degradation of the mask (from absorbed energy) will increase its cost, particularly in a large format projector, such as one using a 10.4" diagonal LCD (liquid cystal display).

We have also found that a mask with a well-defined straight edge, placed sufficiently far from the object plane (CRT phosphor, slide, light-valve or LCD) for its edge to be softened by defocus requires a position so far from the object plane that it is usually already occupied by either the projection or illumination optics. Moreover, in a simple projector (such as an overhead projector) where there is room for such a mask chromatic aberration in the illumination optics means that the mask preferentially blocks certain colours, leading to an objectionable colouration of the blend region, and removing the chromatic aberration would significantly increase the cost of the projector.

GB 670111 describes a cine film projection apparatus in which a pair of intermittent motion projectors project onto a screen images that slightly overlap each other along one vertical edge. Each projector has a conventional rotating shutter to obscure film movement and, driven by the same mechanism, an oscillating mask that is positioned close to the film gate so as to extend saw teeth into the path of illumination light directed at the edge region of the film frame that will be projected into the area of overlap on the screen. The size of the teeth depends on the desired width of overlap area on the screen and on the intended stroke through which the mask is oscillated. To obtain uniform gradation of the light intensity in the overlap area, the mask is moved through a stroke at least equal to the width of the base of one of the teeth. The oscillation is substantially parallel to the edge along which the teeth lie.

According to the present invention there is provided apparatus for projecting an image, comprising means defining an object surface for a luminous object in relation to an optical projection system, and, in a surface substantially parallel to or uniformly spaced from the object surface, a comb-like opaque mask so shaped and arranged with its tines extending into the

path for light from the object surface to the projection system, or into the path for light for illuminating an object in the object surface, as in operation to provide a gradual decrease in light transmitted therethrough as a function of distance from the optical axis of the projection system with the mask held stationary relative to the object surface with a spacing therefrom of not less than:-

$$\frac{D \times P}{A}$$

where D is the distance from the object surface to the projection system, P is the pitch of the tines of the mask, and A is the aperture of the projection system.

The invention will now be described by way of example with reference to the accompany drawings, in which:-

FIGURE 1 is a plan view of a comb-like mask for use in accordance with the invention;

FIGURE 2 is a plan view of a first embodiment of apparatus according to the invention; and

FIGURE 3 is a plan view of a second embodiment of apparatus according to the invention.

The mask shown in Figure 1 is made from thin opaque material. At the tip of the tines its optical transmission is 100%. At their base it is zero. The depth of the tines determines the width of the blend region. The pitch of the tines is made sufficiently fine for individual tines to be blurred into their neighbours by the amount of defocussing caused by their distance from the object surface, with the mask held stationary in a plane substantially parallel to the object surface which in this case is a plane. In Figure 1 the tines are triangular and there is no gap between the bases of adjacent tines. The length of each tine is four times the size of its base but could be more or less.

The mask is used at a selected distance from the object surface with the tines pointing towards a straight line intersecting the optical axis of the projection system. The tips of the tines are most easily blurred, so the physical edge of the mask does not produce a brightness step in the picture.

The mask then serves as an optical component whose transmission varies linearly from 100% to zero over a defined region, with no light losses over the rest of the field.

covering only the blend region, the component is small, simply mounted and easily aligned. Since it can be made from an opaque material such as metal and absorbs little energy, it has good long-term stability.

Edge-blend quality is independent of picture geometry or scene brightness. There is very little edge colouration. If tine pitch is very small, the mask can be made by laser cutting or photo-chemical etching. The latter method should produce particularly cheap masks in quantity.

If tine pitch is very small, the profile of the tines may need to be modified to allow for the effects of diffraction.

As an example of use, Figure 2 shows the position of a plurality of the masks in a simple projector based on the overhead projector format and using a 10.4" LCD as the object. Two masks provide blending on the left and right edges of the projected image. A tine height of 10 mm and pitch of 1 mm is satisfactory.

Light is emitted by a projector lamp 11 and gathered by a condenser lens 12. Light passing through the condenser lens 12 is directed to a Fresnel lens 13 which changes the vergence of light to illuminate a liquid crystal display panel 14 arranged to define an object plane of an optical projection system represented by a projection lens 15 having an optical axis 16. Two edge-blend masks 17 and 18, each as described hereinbefore with reference to Figure 1, are arranged in a plane parallel to the object plane with their tines extending into the path of light from the left and right hand margins of the display panel 14 to the projection lens 15. In this embodiment the plane of the masks 17 and 18 lies between the object plane and the projection lens 15. The lens 15 produces a sharply focussed image of the display panel 14 on a screen (not shown) in the usual manner. Means (not shown) are provided to enable the position of each mask to be adjusted towards and away from the optical axis 16 so that optimum positions for blending can be obtained when a like projection apparatus is placed next to the apparatus of Figure 2 at its right hand side and its left hand side. Such adjustments are best judged by the user observing the effect on the adjacent overlapped projected images.

The display panel 14 may provide still or moving

pictures.

A further example is shown, in Figure 3, where masks are placed on the illumination optics' side of the object. A mask can lie on either side of a Fresnel lens, which can form its physical support.

The projection apparatus of Figure 3 is similar to that of Figure 2 and is adjusted in the same way. Elements in Figure 3 corresponding to those in Figure 2 have the same reference numerals as in Figure 2.

One pair of the four masks, 19, 20, 21, and 22 would be used, the two chosen being on opposite sides of the optical axis 16.

In another arrangement in which nine projectors are used to project a composite picture, the central projector is equipped with four masks. The end portions of adjacent ones of these four masks overlap, and adjacent masks are disposed in different planes perpendicular to the optical axis of the projector. The planes for adjacent masks are sufficiently far apart in the direction of the optical axis for independent defocussing of the four masks to be possible.

To ensure that the projection of the tines of a mask is defocussed at the screen on which the projection system sharply focusses an image of the display panel 14 or other planar luminous object, such as a flat cathode ray tube screen, the mask must be held at a distance from the object plane measured in the direction parallel to the optical axis of the projection system, of not less than

$$\frac{D \times P}{A}$$

where D is the distance from the object plane to the projection system, P is the pitch of the tines of the mask, and A is the aperture of the projection system. This criterion is approximate, and it will be found that as a result of the asymmetry in depth of field on opposite sides of the object plane, satisfactory defocussing can be achieved with the mask nearer to the object plane if it is situated between the object plane and the projection system than if it is situated between the object plane and the illumination optics, where the apparatus requires illumination optics.

In an apparatus in which the luminous object is a

liquid crystal display panel or other planar transparent object requiring illumination optics, the mask or masks should be held as close to the object plane as possible, within the limit that must be observed in order to obtain the required defocussing, since colouration of the projected image by interaction between the mask and the chromatic aberration of the illumination optics is then minimised. Where there remains some colouration, the predominant colour of the scenes to be projected, if either bluish or orange-tinged can be taken into account, since the colouration is blue if the mask is held between the object plane and the projection system and is orange if the mask is held between the object plane and the illumination optics.

In an embodiment in which the luminous object is the face of a cathode ray tube (CRT) having a concave face, the or each mask is so shaped that it can lie in a surface of substantially the same shape so as to be held with its tines all at substantially the same distance from the CRT face surface. Similarly, the or each mask would be non-planar for a convex CRT face surface, the mask or masks being shaped to lie in a surface substantially uniformly spaced from the convex CRT face surface.

In relation to an object surface that is not planar, the observations made hereinbefore regarding the spacing criterion and chromatic aberration colouration in connection with planar object surfaces also apply but with account being taken where necessary of the object surface not being planar.

In the formula

$$\frac{D \times P}{A}$$

the aperture A is the diameter of the entrance pupil, which is sometimes known as the clear aperture, or, where the illuminating does not completely fill the entrance pupil, the diameter of that part of the entrance pupil which is filled by the illuminating light. For example, a mask with a tooth pitch of 1mm that is 240mm from a projection lens with an effective aperture of 10mm (the diameter of the image of the filament of the source of illumination in this example) will be out of focus at about 24mm from the plane of a film or liquid crystal display panel illuminated by the filament of the source.

CLAIMS :

1. Apparatus for projecting an image, comprising means defining an object surface for a luminous object in relation to an optical projection system, and, in a surface substantially parallel to or uniformly spaced from the object surface, a comb-like opaque mask so shaped and arranged with its tines extending into the path for light from the object surface to the projection system, or into the path for light for illuminating an object in the object surface, as in operation to provide a gradual decrease in light transmitted therethrough as a function of distance from the optical axis of the projection system with the mask held stationary relative to the object surface with a spacing therefrom of not less than

$$\frac{D \times P}{A}$$

where D is the distance from the object surface to the projection system, P is the pitch of the tines of the mask, and A is the aperture of the projection system.

2. Apparatus according to claim 2, wherein a further comb-like mask is provided in a surface substantially parallel to or uniformly spaced from the object surface and is so shaped and arranged with its tines extending into the path for light from the object surface to the projection system, or into the path for light for illuminating an object in the object surface, as in operation to provide a gradual decrease in light transmitted therethrough as a function of distance from the optical axis of the projection system, the tines of the further mask extending in substantially the opposite direction to those of the first said mask, the two masks being on opposite sides of the said optical axis, and the further mask being held stationary relative to the object surface with a spacing therefrom of not less than

$$\frac{D \times P}{A}$$

3. Apparatus according to claim 1 or 2, wherein the means defining an object surface includes the face of a cathode ray tube and the or each mask is disposed between the object surface

and the projection system.

4. Apparatus according to claim 3, wherein the face of the cathode ray tube is non-planar and the or each mask is correspondingly non-planar.

5. Apparatus according to claim 1 or 2, wherein means including a source for emitting light are provided for illuminating a planar transparent object located in the object surface, and the or each mask is disposed between the object surface and the source.

6. Apparatus according to claim 2, wherein a further pair of comb-like masks is provided, each mask of the further pair being disposed in a surface substantially parallel to or uniformly spaced from the object surface and being so shaped and arranged with its tines extending into the path for light from the object surface, to the projection system, or into the path for light for illuminating an object in the object surface as in operation to provide a gradual decrease in light transmitted therethrough as a function of distance from the optical axis of the projection system, the tines of the masks of the further pair extending in substantially opposite directions to one another, the masks of the further pair being on opposite sides of the said optical axis, the respective end portions of adjacent ones of the four masks overlapping as viewed parallel to the optical axis, and each of the further pair of masks being held stationary relative to the object surface with a spacing therefrom of not less than

$$\frac{D \times P}{A}$$

7. Apparatus according to any preceding claim, wherein the or each mask is so mounted as to be adjustable towards and away from the said optical axis.

8. Apparatus substantially as described hereinbefore with reference to Figure 2 or Figure 3 of the accompanying drawings.

9. A multi-projector apparatus including two projecting

apparatus, each according to any one of claims 1 to 8, wherein the two apparatuses are so arranged next to each other that in operation respective gradually decreased margins of the images projected thereby substantially completely overlap.

10. Apparatus according to any one of claims 1 to 8, wherein the tines of the or each mask are substantially triangular in a surface defined by the mask, and there is substantially no gap between the respective bases of adjacent tines.

11. Apparatus according to claim 10, wherein the length of each tine is substantially four or more times the size of its base.

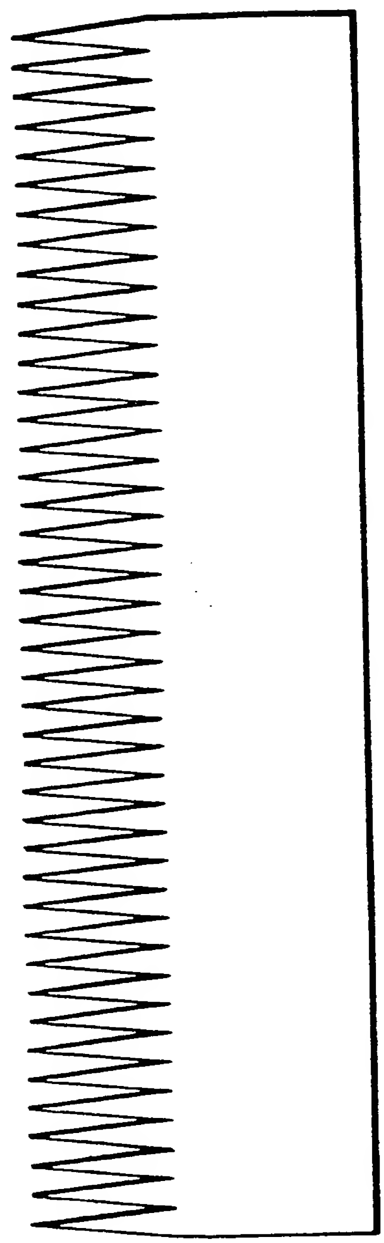

FIG.1.

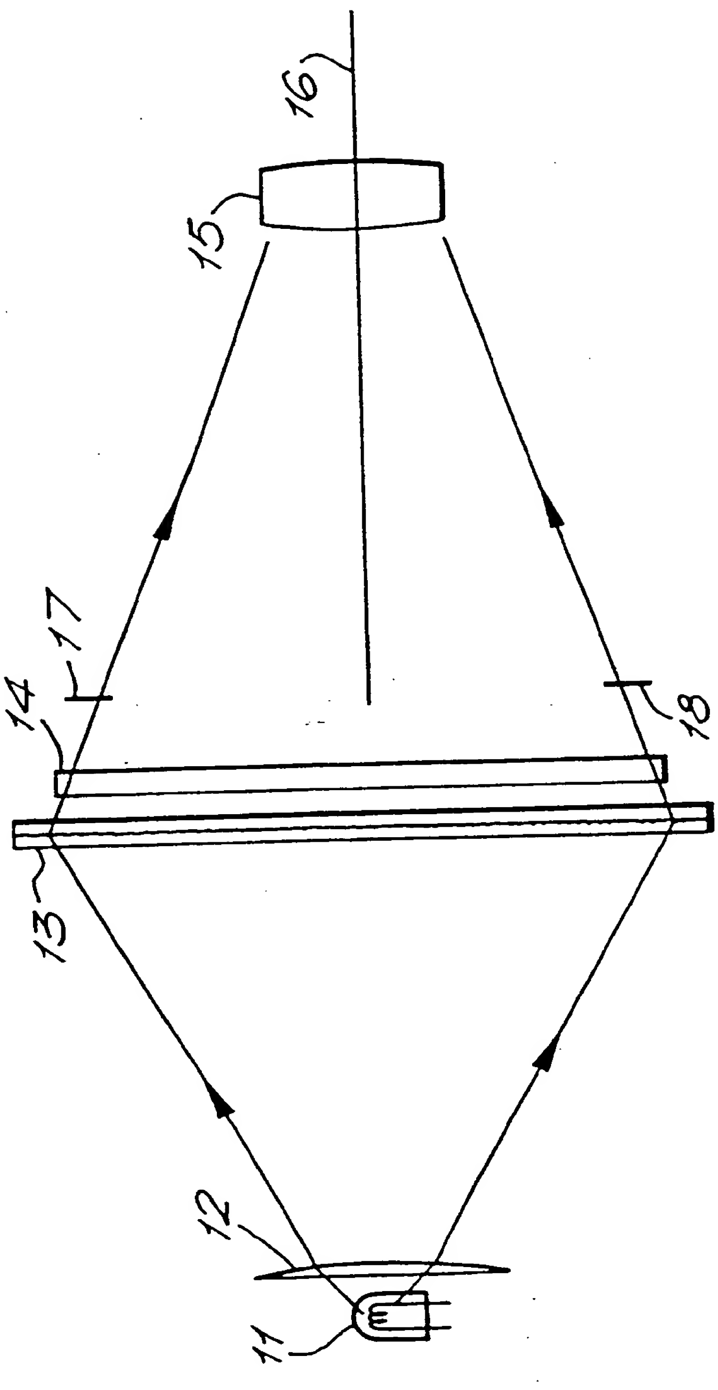

FIG.2.

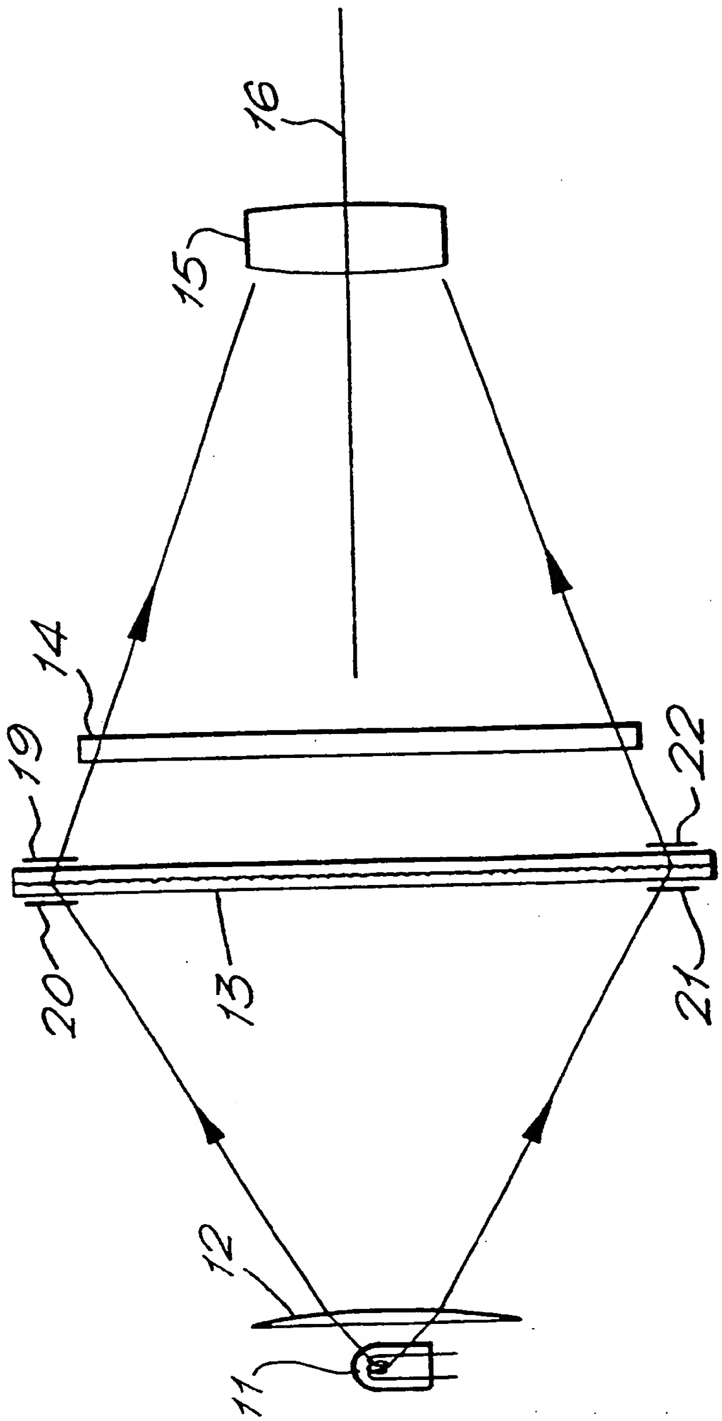

FIG.3.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 95/00624

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G03B21/13

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB-A-670 111 (SUTCLIFFE) 16 April 1952 cited in the application see page 6; claim 1; figures 2,7 ---	1,2,5,7, 9,10
A	DE-A-37 44 060 (KREBS) 13 July 1989 see abstract; figures 1,2 ---	1,2,5,7, 10
A	DE-A-40 31 053 (SACHER) 2 April 1992 see claim 1; figure 1 ---	1,2,9
A	FR-A-2 504 695 (SARL MACRESY-CREATIONS SIMON) 29 October 1982 see claim 1; figure 8 -----	1,2,5,7, 9,10

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Inte..onal Application No
PCT/GB 95/00624

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A-670111		NONE	
DE-A-3744060	13-07-89	NONE	
DE-A-4031053	02-04-92	NONE	
FR-A-2504695	29-10-82	NONE	